REMARKS

Favorable reconsideration and allowance of the claims of the present application are respectfully requested.

In the present Office Action, Claims 31-38, 40-42, 45, and 47-49 stand rejected under 35 U.S.C. §103(a) as allegedly unpatentable over U.S. Patent No. 5,716,875 to Jones Jr., et al. ("Jones Jr., et al.") in view of U.S. Patent No. 6,015,989 to Horikawa, et al. ("Horikawa, et al."). Claims 43-44 stand rejected under 35 U.S.C. §103(a) as allegedly obvious over the combination of Jones Jr., et al., Horikawa, et al., and U.S. Patent No. 6,322,849 to Joshi, et al. ("Joshi, et al."). Applicants respectfully traverse the aforementioned §103 rejections in view of the remarks present hereinbelow.

Applicants provide a ferroelectric (FE) capacitor and a method of fabricating the same. More specifically, the present invention relates to a method of fabricating an integrated ferroelectric/CMOS structure comprising the steps of: forming at least one complementary metal oxide semiconductor wafer; forming a ferroelectric capacitor over said CMOS device, where the ferroelectric capacitor comprises at least a ferroelectric layer 22 and an oxygen source layer 26 in proximity to a conductive electrode layer 20, where said oxygen source layer 26 is a metal oxide having the formula MO_x, *wherein M is a noble metal, a non-noble metal or mixtures and alloys thereof and z is from about .03 to about 3,* and is capable of at least partially decomposing at temperature below 700°C; then forming wiring levels 32 on the ferroelectric capacitor at temperatures below 450°C; and annealing the structure at a temperature between 300°C and 700°C so as to at least partially decompose the oxygen source layer to release oxygen into the ferroelectric capacitor. *The atomic percent of oxygen*

in the oxygen source layer, having the formula MO_x where x is from about .03 to about 3, is from about 1.5% to about 25%.

Applicants submit that the claims of the present application are not made obvious from the disclosures of Jones Jr., et al., Horikawa, et al., and Joshi, et al., since none of the applied references teaches or suggests applicants' claimed method that includes the step of: "forming a ferroelectric capacitor over said CMOS device, said ferroelectric capacitor comprising at least a ferroelectric layer and an oxygen source layer in proximity to a conductive electrode layer, *where said oxygen source layer is a metal oxide having the formula MO_x, wherein M is a noble metal, a non-noble metal or mixtures and alloys thereof and x is from about 0.03 to about 3, and is capable of at least partially decomposing at temperatures below 700°C*", as recited in Claim 31.

The primary reference, i.e., Jones Jr., et al., fails to teach or suggest a method including the step of depositing an oxygen source layer, where the oxygen source layer is *a metal oxide having the formula MO_x, wherein M is a noble metal, a non-noble metal or mixtures and alloys thereof and x is from about 0.03 to about 3*. Jones Jr., et al. disclose a method for forming CMOS transistors including annealing the transistor in a hydrogen atmosphere to introduce hydrogen into the transistor structures. Following an annealing step, a layer of SiN is formed atop the transistors to prevent the outdiffusion of hydrogen during further processing. Applicants observe that the Examiner has admitted in the present Office Action that, "Jones Jr., et al., does not specifically show forming the oxygen source layer in proximity to a conductive electrode layer and releasing oxygen from the oxygen source layer." *See* Office Action, Page 3, paragraph 3. Therefore, since Jones Jr., et al. fail to teach or suggest an oxygen source layer, the principal reference also fails to teach or suggest that

the oxygen source layer is a *metal oxide having the formula MO_x, where x is from about 0.03 to about 3,* as recited in Claim 31 of the present application.

The applied secondary reference, i.e., Horikawa, et al., does not alleviate the above defect in Jones Jr., et al., since Horikawa, et al. also do not teach or suggest a method which forms the claimed oxygen source layer having the *formula MO_x, where x is from about 0.03 to about 3.* Horikawa, et al. disclose a semiconductor device having a lower capacitor electrode 130 connected electrically with the major surface of the semiconductor substrate 101 through the connecting member 110; a capacitor dielectric film 115 formed on the lower capacitor electrode 130; an upper capacitor electrode 116 formed on the capacitor dielectric film 115; and a second interlayer insulating film 117 formed on the capacitor upper electrode 116. The lower electrode 130 is made of a principal component selected for the group consisting of ruthenium and iridium and contains oxygen in a quantity of 0.001% to 0.1% by atomic weight %.

Horikawa, et al. fail to teach forming an oxygen source layer having the *formula MO_x, where x is from about 0.03 to about 3*, because the oxygen concentration of the lower capacitor electrode disclosed in Horikawa, et al., is not within the oxygen concentration of applicants' oxygen source layer. In the claimed method, the source layer has the formula MO_x, where x ranges from about 0.03 to about 3. This correlates to an oxygen content from about 1.5 to about 25 % by atomic weight %. The lower capacitor electrode 130 disclosed in Horikawa, et al. contains oxygen in a quantity of 0.001 to 0.1 % by atomic weight %. Horikawa, et al. thus provide a structure in which the oxygen content is over an order of magnitude *lower* than the oxygen content in the claimed method. Therefore, Horikawa, et al. fail to teach or suggest a method of forming a ferroelectric capacitor comprising at least a

ferroelectric layer and an oxygen source layer in proximity to a conductive electrode layer, where said oxygen source layer is a metal oxide having the formula MO_x, where M is a noble metal, a non-noble metal or mixtures and alloys thereof and x is from about 0.03 to about 3, and is capable of at least partially decomposing at temperatures below 700°C", as recited in Claim 31.

Applicants observe that Horikawa, et al. make a single reference to a lower capacitor electrode having an oxygen concentration of about 2% during initial anneal process steps. *See* Column 9, lines 24-37. Applicants submit that this reference is to an intermediate process step, where ultimately the lower capacitor electrode is further annealed until the oxygen concentration of the lower capacitor electrode is within the desired range of 0.001 to 0.1 atomic %. Referring to Column 9, lines 24-35, Horikawa, et al. disclose that:

> "annealing under the oxygen atmosphere for 120 minutes at 400°C to 600°C has resulted in diffusion of oxygen into the iridium thin film to allow the latter to contain oxygen in a quality of about 2%. *When the subsequent annealing at 400°C to 600°C for 60 minutes results in release of oxygen from the iridium thin film to reduce the oxygen content in the iridium to thereby control the oxygen content to a desired value, that is within the range of .001 to 0.1%.* In this way, the oxygen content in the iridium film can be controlled to the desired value by effecting the annealing after formation of the iridium film forming the lower capacitor electrode."

"It is impermissible within the framework of §103 to pick and choose from any one reference only as much of it as will support a given position, to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggest to one of ordinary skill in the art". *In re Wesslau,* 147 U.S.P.Q. 391, 393 (1965). Therefore, Horiwaka, et al. do not teach or suggest forming an oxygen source layer that is a metal oxide having the formula MO_x, where x is from about 0.03 to about 3. Additionally, since Horikawa, et al. disclose that it is desired

to control the oxygen content to a range of 0.001 to .1%, Horikawa, et al. teach away from applicants' claimed method that produces a source layer having an oxygen content ranging from about 1.5 to about 25 atomic %. A prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention. *W.L. Gore and Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983). Therefore, Horikawa, et al. teach away from applicants' claimed method, as recited in Claim 31.

Joshi, et al. also fail to fulfill the deficiencies of the applied prior art. More specifically, Joshi, et al. do not teach or suggest forming an oxygen source layer having the formula MO_x, where x is from about 0.03 to about 3. Joshi, et al. provide a method for fabricating a ferroelectric integrated circuit that reduces or eliminates the degradation of electronic properties resulting from exposure to hydrogen. Joshi, et al., referring to FIG. 1, disclose a ferroelectric capacitor 118 comprising a bottom electrode 120 made of platinum and having a thickness of 2000 Å. Joshi, et al. do not teach or suggest a method including the step of forming a ferroelectric thin film 122 formed on the bottom electrode 120, and the top electrode 124 formed on the ferroelectric film 122, made of platinum and having a thickness of 2000 Å. Joshi, et al. do not teach or suggest a method including the step of "forming a ferroelectric capacitor over said CMOS device, said ferroelectric capacitor comprising at least a ferroelectric layer and *an oxygen source layer* in proximity to a conductive electrode layer, *where said oxygen source layer* is a metal oxide having *the formula MO_x, where x is from about 0.03 to about 3*, as recited in Claim 31.

In addition to failing to teach or suggest an internal oxygen source layer, Joshi, et al. teach away from utilizing an oxygen annealing ambient. Joshi, et al. disclose that high

temperature oxygen annealing disadvantageously generates defects in silicon crystalline structures. *See* Column 2, lines 20-27. Joshi, et al. further disclose that eliminating high temperature O_2 recovery annealing and utilizing a high temperature inert gas recovery anneal advantageously reverses the effects of hydrogen degradation. *See* Column 2, lines 55-63. Therefore, since Joshi, et al. fail to disclose an oxygen source layer and teach away from utilizing an annealing ambient that comprises oxygen, Joshi, et al. lead away from applicants' claimed method as recited in Claim 31.

The §103 rejection also fails because there is no motivation in the applied references which suggest modifying the disclosed methods and structures to include the various features, particularly the claimed method including forming a ferroelectric capacitor over said CMOS device, said ferroelectric capacitor comprising at least a ferroelectric layer and an oxygen source layer in proximity to a conductive electrode layer, *where said oxygen source layer is a metal oxide having the formula MO_x, where x is from about 0.03 to about 3.* "The mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." *In re Vaeck*, 947 F.2d 488, 493, 20 USPQ 2d. 1438, 1442 (Fed. Cir. 1991).

Despite failing to provide a reference that teaches or suggests a metal oxide oxygen source layer having the formula MO_x, where x is from about 0.03 to about 3, the Examiner maintains the 35 U.S.C. §103(a) rejection by inappropriately relying on the U.S. Court of Appeals for the Federal Circuit decision in *In re Woodruff*, 919 F.2d 1575, 16 U.S.P.Q.2d 1934, (Fed. Cir. 1990). The Examiner misinterprets *In re Woodruff* for the proposition that applicants' *have failed to provide where the claimed range is critical by showing that the claimed range achieves unexpected results in comparison to the prior art range.* Applicants

respectfully disagree and submit that th Examiner has applied the above passage of *In re Woodruff* in a manner that is inconsistent with a proper prima facie analysis of obviousness under 35 U.S.C. §103(a).

Applicants note that it is the initial burden of the Examiner to support a prima facie conclusion of obviousness. Only after the Examiner produces a prima facie case of evidence does the burden shift to the applicant who may then submit arguments or evidence proving non-obviousness. *See In re Rinehart*, 531 F.2d 1048, 189 U.S.P.Q. 143 (CCPA 1976). To establish a prima facie case of obviousness three criteria must be met. First there must be some suggestion or motivation, either in the references themselves or the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. *Finally, the prior art reference or references combined must teach or suggest all of the claimed limitations. See Hodosh v. Block Drug Co., Inc.,* 786 F.2d 1136, 1143, 225 USPQ 182, 187 (Fed. Cir. 1986). Applicants note, as discussed above, that the Examiner has failed to provide references, whether alone or in combination, which teach or suggest all the limitations of applicants' claimed method and therefore fails to provide a prima facie conclusion of obviousness.

The passage cited by the Examiner from *In re Woodrich* is inapplicable to the facts of the present application, because the prior art discussed by the court in *In re Woodrich* disclosed each and every limitation of the claimed invention examined by the court. More specifically, a claimed range of each constituent of a claimed fungal growth inhibitor composition in *In re Woodrich* was overlapped by a prior art composition, where the prior art was directed to retarding deterioration changes in vegetables. The court in *In re Woodrich* held that the claimed range of the fungal growth inhibitor, which was overlapped by the

previously known composition for retarding deterioration, was not patentable subject matter since the alleged distinction between the claimed composition and the prior art was a "new use" that was at least generically covered by the prior art. The court further stated that in the above situation in order to secure patentability the applicant typically must show that the particular range is critical, generally by showing that the claimed range achieves unexpected results. *See In re Woodruff*, 919 F.2d 1575, 16 U.S.P.Q.2d 1934, (Fed. Cir. 1990).

The present application is factually distinct from the facts of *In re Woodrich*. The prior applied in *In re Woodrich* disclosed each and every limitation of the claimed invention. A prima facie case of obviousness was established in *In re Woodrich* that shifted the burden to proving non-obviousness to the applicant. In *In re Woodrich* the burden was on applicant to prove that the claimed range, which overlapped the prior art, was critical to the claimed invention. In the present application, the applied prior art oxygen range fails to overlap applicants' claimed oxygen range and therefore fails to teach each and every limitation of the applicants' claimed method. Since the applied prior art fails to teach each and every aspect of the claimed invention, the Examiner has failed to produce a prima facie case of obviousness and the burden to prove non-obviousness has not been shifted to the applicants. Therefore, since a prima facie case of obviousness has not been established it is improper for the Examiner to maintain the instant rejection on the basis that applicants have failed to show that the claimed oxygen range is critical to achieving unexpected results.

Applicants maintain that the claimed oxygen range is a clear distinction between applicants' method and the prior art. Applicants have disclosed that the present invention provides a method of manufacturing integrated ferroelectric/CMOS structures, where the claimed oxygen concentration is present such that the storage characteristics of the integrated

structure is improved upon at least partial release of the oxygen. Applicants further disclose that improved storage characteristics are achieved by utilizing an oxygen source layer in the integrated structure, in which the oxygen release temperature is preferably low enough to allow substantial oxygen release without substantial damage to the integrated structure, yet high enough to insure that complete oxygen release does not occur during BEOL processing.

Horikawa, et al., the sole reference applied by the Examiner to allegedly provide a capacitor electrode comprising oxygen, incorporates oxygen at a concentration that is at least an order of magnitude less than the claimed oxygen concentration. Horikawa, et al., incorporate oxygen into a lower electrode in order to avoid deformation of the electrode during high temperature processing. To summarize, Horikawa, et al. fail to disclose an oxygen range that overlaps applicants' claimed oxygen range and Horikawa, et al. do not recognize that the partial release of oxygen increases the memory characteristics of a ferroelectric capacitor, in which the oxygen is incorporated. Therefore, one of ordinary skill in the art would not be able to produce applicants' claimed method through routine experimentation and optimization of the oxygen range disclosed in the method taught by Horikawa, et al.

In order for Horikawa, et al. to be optimized to the meet the limitation of applicants' claimed oxygen range, the prior art reference must at least provide an overlapping oxygen range and recognize the functional relationship of partially released oxygen to increased memory characteristics, as disclosed by the applicants. See *In re Antonie,* 559 F.2d 618, 195 U.S.P.Q. 6 (CCPA 1977)(Recognition of functionality is essential to the obviousness of conducting experiments for optimization). Therefore, since Horikawa, et al. are not directed to providing an oxygen concentration in which storage characteristics are improved upon at

least partial release of the oxygen and since Horikawa, et al. disclose an xygen concentration that is an order of magnitude *different* from applicants' claimed method, applicants' claimed oxygen range is not a matter of routine optimization and experimentation.

Applicants further disclose that even if Horikawa, et al. disclosed an oxygen range which overlapped applicants' claimed oxygen range, which the prior art reference does not, Horikawa, et al. still fail to render applicants' claimed method obvious. An applicant can rebut a prima facie case of obviousness of a claimed invention created by a prior art reference that discloses a range that touches the range recited in the claim by establishing the existence of unexpected properties in the range claimed *or that the art in any material respect taught away from the claimed invention. See In re Geisler,* 116 F.3d 1465, 1469, 43 USPQ2d 1362, 1365 (Fed. Cir. 1997). "A reference may be said to *teach away* when a person of ordinary skill, upon the reading the reference would be discouraged from following the path set out in the reference or would be lead in a direction divergent from the path that was taken by the applicant." *In re Gurley,* 7 F.3d 551, 31 USPQ2d 1130 (Fed. Cir. 1994).

Applicants submit that Horikawa, et al. teach away from the present invention. Horikawa, et al. disclose that a low concentration of oxygen in the lower capacitor electrode suppresses the diffusion of Si in order to reduce the formation of a silicide on the lower electrode. Horikawa, et al., referring to Column 8, lines 10-36, further disclose that it is disadvantageous, "if the oxygen content in the ruthenium thin-film is increased to a value not lower than 0.05%, it appears that the use of the annealing temperature of 650°C may result in an increase of the contact resistance by 2 to 3 units. This appears because the oxygen added to the ruthenium becomes excessive." Horikawa, et al. teach away from incorporating higher

concentrations of oxygen, which are on the order of the oxygen concentration in applicants' claimed method, as recited in Claim 31.

It is improper to combine or modify references where the references teach away from their combination or modification. *See In re Graselli*, 713 F.2d 731, 743, 218 USPQ 769, 779 (Fed. Cir. 1983). Therefore, since Horikawa, et al. teach away from being modified to include applicants' claimed *oxygen source layer having the formula* MO_x, *where x is from about 0.03 to about 3*, Horikawa, et al. may not be modified or combined with other prior art methods to provide the applicants' claimed method, as recited in Claim 31.

The rejection under 35 U.S.C. §103 has been obviated; therefore reconsideration and withdrawal thereof are respectfully requested.

Thus, in view of the foregoing amendments and remarks, it is firmly believed that the present case is in condition for allowance, which action is earnestly solicited.

Respectfully submitted,

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